Extending a Missions and Means Framework (MMF) Demonstration to Vulnerability/Lethality Data Production

Beth Ward
U.S. Army Research Laboratory

ITEA Modeling and Simulation Workshop
December 14, 2005

Presented by Beth Ward
beth@arl.army.mil

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
DEC 2005		**00-00-2005 to 00-00-2005**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Extending a Missions and Means Framework (MMF) Demonstration to Vulnerability/Lethality Data Production	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Research Laboratory,Computational and Information Sciences Directorate,White Sands Missile Range,NM,88002**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Modeling and Simulation Conference, 2005 Dec 12-15, Las Cruces, NM

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**19**	

Objective

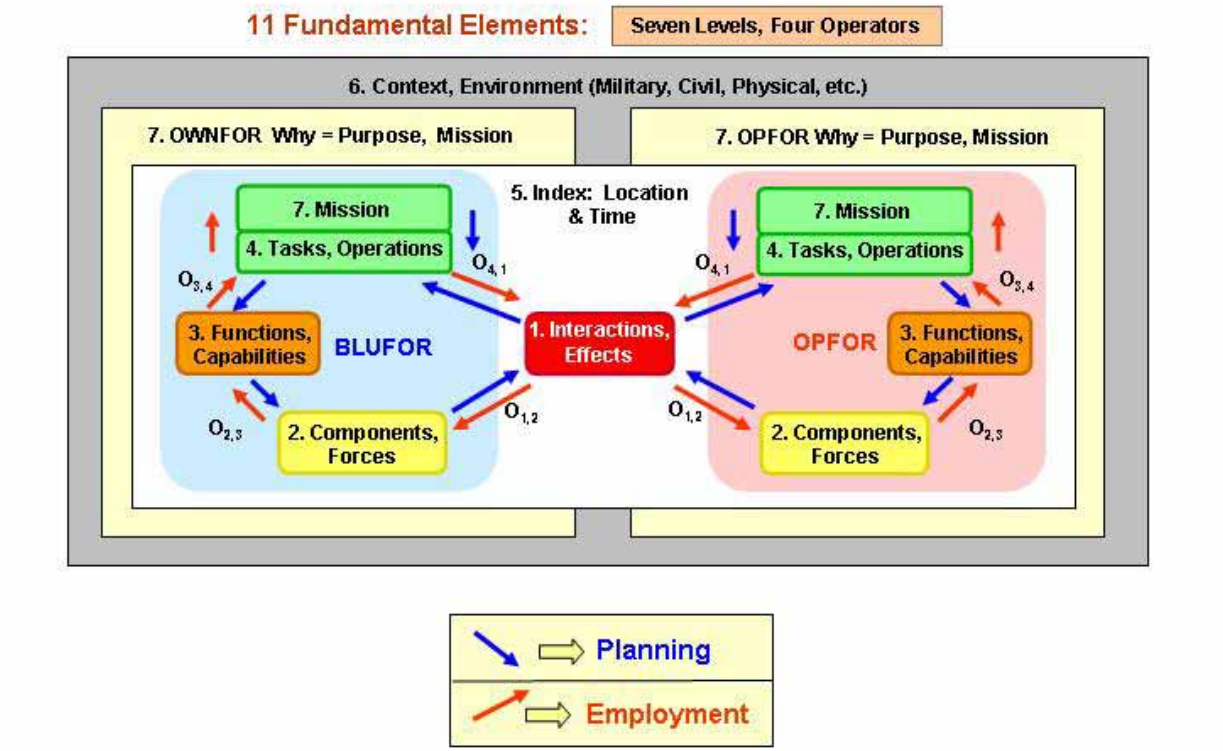
To present the data production process for the 2005 MMF demonstration and how lessons learned can be applied in the future.

Outline

- MMF: *What's different*
- Demonstration Models and Data
- Data Development Process
- Status
- Implications

MMF Demonstration:
What's Different?

- Direct application of war fighter tasks.
- Demonstration of network-centric effects that features
  - SoS-level fault trees
  - **<u>Degraded Capability States (DCS) at both platform and component levels</u>**
  - Dynamic effects of vulnerability, reliability, repair, …
  - Alternative courses of action



MMF Data:
What's Different?

Traditionally

- System developer, user and evaluator determine a Damage Assessment List of critical Line-Replaceable-Units (LRU).
- A conclave is formed to assign a weighting to each LRU representing the loss to mission effectiveness across all scenarios and environment conditions.
- Limiting metrics; mobility, firepower, communications and catastrophic.
- Developmental test information was not incorporated into V/L modeling.

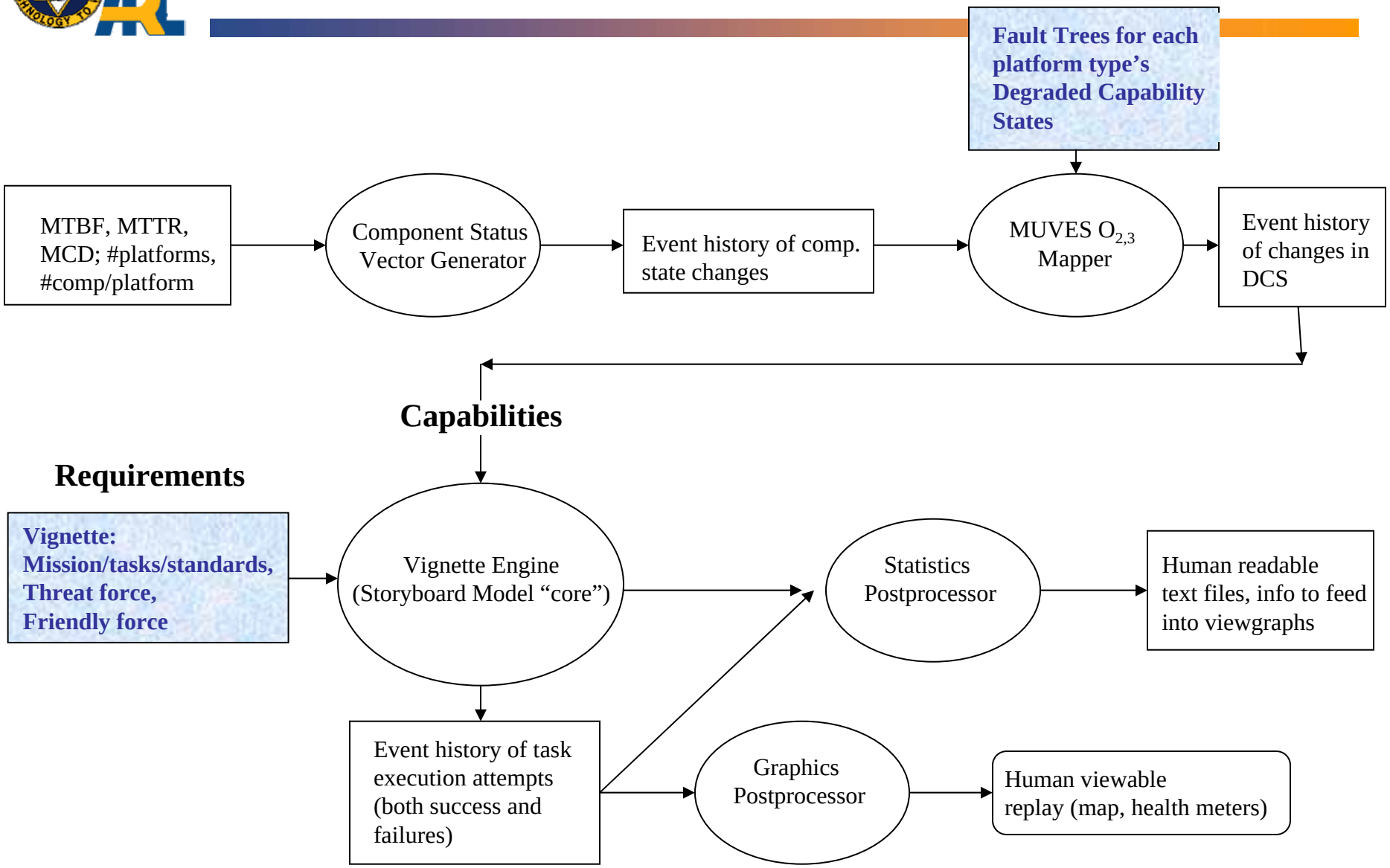
What's NEW

- Data development is directly correlated to the Army Universal Task List (AUTL), Joint Universal Task List (UJTL) or Lead System Integrator tasks.
- Expanded metrics support a robust system representation required for a system of systems evaluation and training.
- A closer communication between the modeling, testing and soldier community.

What's missing is metric validation via developmental testing.

MMF Demonstration:

Models and Data



Data Development Process:
Overview

1. **Determine platform engineered capability elements (engineer/design contractor).**
2. **Perform criticality analysis and develop system fault trees (engineer/analyst).**
3. **Determine semantic and design constraints (engineer/analyst).**
4. **Develop the DCS partially ordered set (Poset) given the constraints (analyst).**
5. **Determine the appropriate tasks typical for platform (AUTL/UJTL).**
6. **Determine the required DCS for each tasks and color code acceptability (TRADOC System Manager).**
7. **Bin the platform poset by tier and acceptability.**
8. **Calculate the probability of available capability at 3 levels (red, amber, green) for each platform task per threat (analyst).**

Process requires closer communications between the modeling, analysis, testing, and training communities.

Degraded Capability States:
Basic Elements

C2V (2)

NLOS (6)

ARV-RISTA (3)

Class-II UAV (3)

Mobility (5)
M0 No Mobility Degradation
M1* Reduced Maximum Speed
M2 Reduced Maneuverability
M3* Stop After T Minutes
M4 Reduced Acceleration
M5 Total Immobilization

Firepower (12)
F0 No Firepower Degradation
F1 Lost Ability To Fire Buttoned Up Main
F2 Degraded Delivery Accuracy of Main
F3 Degraded Initial Rate of Fire of Main
F4 Degraded Subsequent Rate of Fire of Main
F5 Degraded Maximum Range Main
F6 Lost Reload Capability
F7 Total Loss of Firepower Main
F8 Lost Ability to Fire Buttoned Up Secondary
F9 Degraded Delivery Accuracy of Secondary
F10 Degraded Initial Rate of Fire of Secondary
F11 Degraded Subsequent Rate of Fire of Secondary
F12 Total Loss of Firepower Secondary

Communication (8)
X0 No Communication Degradation
X1 Reduced Range
X2* Lost Line-of-Sight (LOS) Data (ex. JTRS)
X3* Lost LOS Voice
X4* Lost Non-LOS Data (ex. SATCOM)
X5 Lost NLOS Voice
X6 Lost Internal Communications
X7 Lost External Communications
X8 Lost All Communications

Survivability (6)
S0 No Survivability Degradation
S1 Lost NBC Protection
S2 Lost Ability to Deploy Obscurants
S3 Lost Silent Watch Capability
S4 Lost Active Protection System
S5 Lost Threat Warning Capability
S6 Lost Fire Suppression Capability

Target Acquisition (3)
A0 No Acquisition Degradation
A1 Lost Daylight Sights
A2 Lost Night Sights
A3 Lost Range Finder

Surveillance (4)
Z0 No Surveillance Degradation
Z1 Lost Primary Sensor
Z2 Lost Secondary Sensor
Z3 Lost Tertiary Sensor
Z4 Lost All Surveillance

Crew (7)
C0 No Crewmember Incapacitated
C1 Commander Incapacitated
C2 Squad Leader Incapacitated
C3 Driver Incapacitated
C4 Operator 1 Incapacitated
C5 Operator 2 Incapacitated
C6 Gunner Incapacitated
C7 Loader Incapacitated

Passengers (1)
P0 No Passengers Incapacitated
P1 Passengers Incapacitated

Other (3)
01 Lost Situational Awareness
02 Lost Unmanned System Control
03 Lost Automated C^2

Catastrophic Loss (1)
K0 No Catastrophic Loss
K1 Lost Every Capability

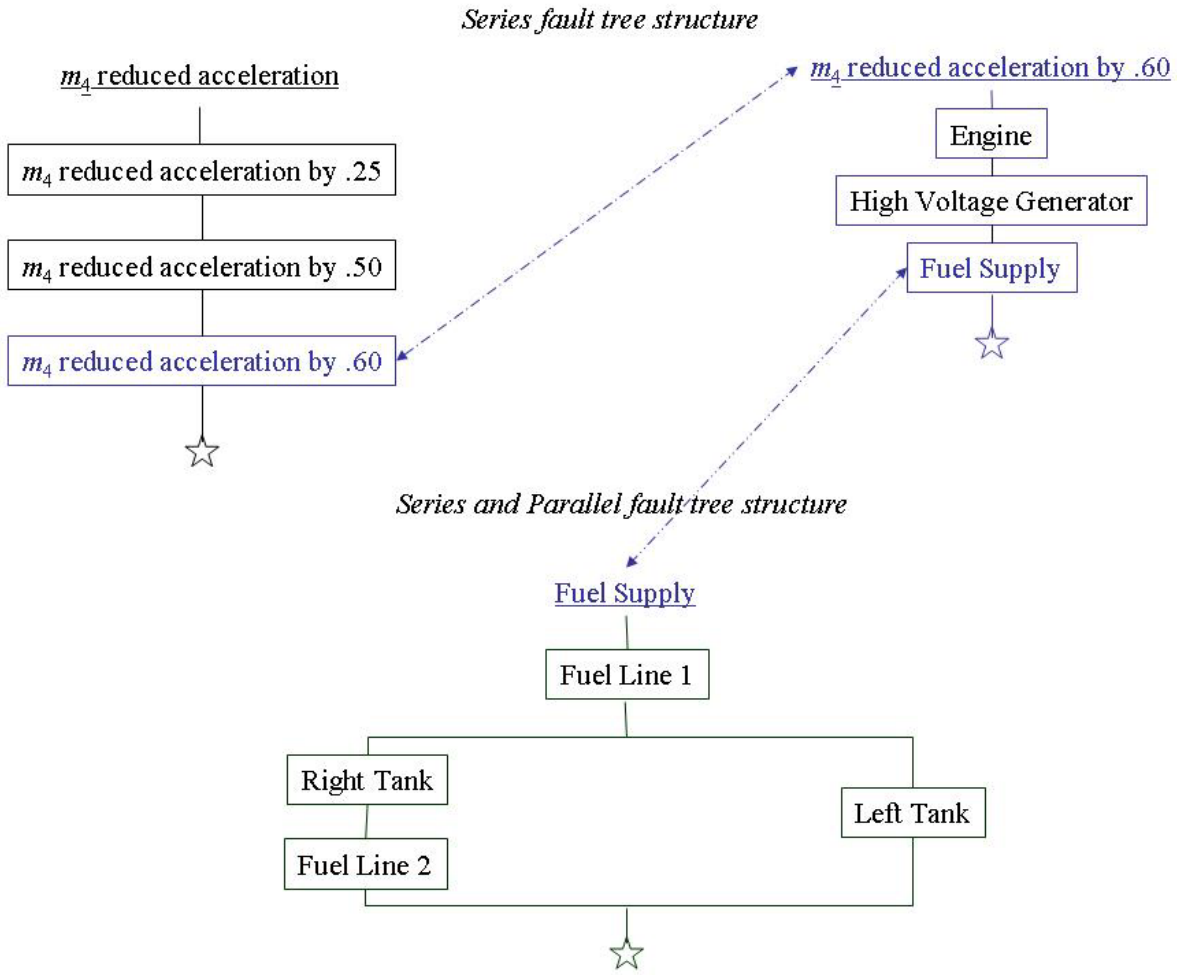
** assigned degradation factor according to the variation in components affecting speed or bandwidth.*

Data Development Process:
Determine Engineered Capabilities

Category	Description	ARV (RSV)	UAV	C2V	NLOS-C
Mobility					
m1	**reduced_maximum_speed**	**x**	**x**	**x**	**x**
m2	**reduced_maneuverability**	**x**	**x**	**x**	**x**
m3	**stop_after_t_minutes (leaks)**	**x**	**x**	**x**	**x**
m5	**total_immobilization**	**x**	**x**	**x**	**x**
Firepower					
f1	**lost_ability_to_fire_buttoned_up_main**	**x**		**x**	
f2	**degraded_delivery_accuracy_main**				**x**
f3	**degraded_initial_rate_of_fire_main**				**x**
f4	**degraded_subsequent_rate_of_fire_main**				**x**
f7	**total_loss_of_firepower_main**	**mg**		**mg**	**howitzer**
f12	**lost_secondary_armament**				**x**
Communications					
x2	**lost_external_data**	**x**	**x**	**x**	**x**
x3	**lost_external_voice**			**x**	**x**
x6	**lost_internal_comms**			**x**	**x**
x8	**lost_all_commo**			**x**	**x**

Data Development Process:

Criticality Analysis and DCS Fault Tree Development



NLOS-C mobility is increased by hybrid electric technology.

Data Development Process:
Determine Constraints

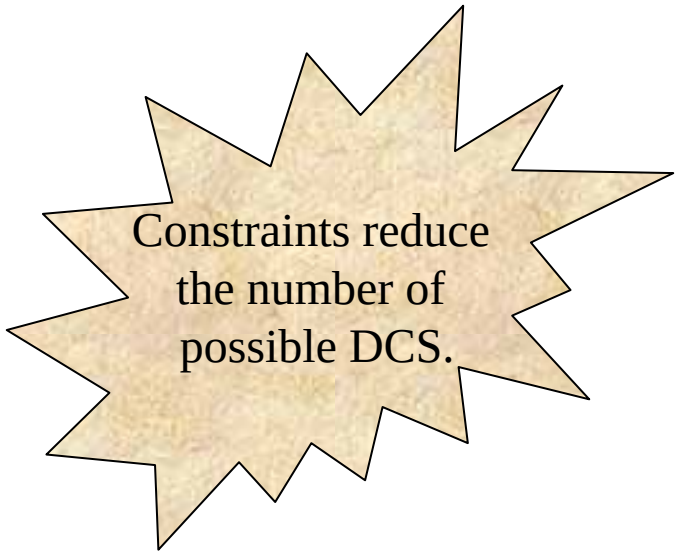
- SEMANTIC constraints imply loss by definition.

  i.e., if x_7 then x_1, x_2, x_3, x_4 and x_5.

- DESIGN constraints imply loss of capability by the engineered component relation.

  i.e., if x_2 then x_3

ID	COMMUNICATION CAPABILITY
X_0	No Communication Degradation
X_1	Reduced Range
X_2	Lost Line-of-Sight (LOS) Data
X_3	Lost LOS Voice
X_4	Lost Non-LOS Data
X_5	Lost NLOS Voice
X_6	Lost Internal Communications
X_7	Lost External Communications
X_8	Lost All Communications



Data Development Process:

Develop Partially Ordered Sets

Of the $2^5 = 32$ subsets of $\{m_1, m_2, m_3, m_4, m_5\}$, the constraint preclude all but these 16:

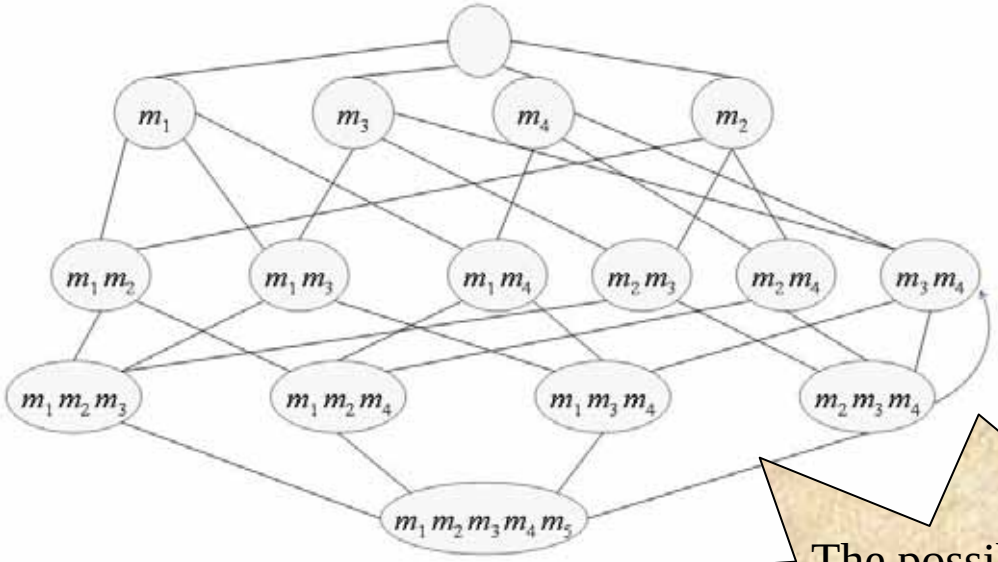
tier 0
- { }

tier 1
- { M1 }
- { M2 }
- { M3 }
- { M4 }

tier 2
- { M1 M2 }
- { M1 M3 }
- { M2 M3 }
- { M1 M4 }
- { M2 M4 }
- { M3 M4 }

tier 3
- { M1 M2 M3 }
- { M1 M2 M4 }
- { M1 M3 M4 }
- { M2 M3 M4 }

tier 4
- { M1 M2 M3 M4 M5 }



16 states in 5 tiers

$\{m_2, m_3, m_4\} \supset \{m_3, m_4\}$

The possible states ordered bottom-to-top by set containment

How the NLOS-C mobility states compare for capability.

Data Development Process:

Determine Appropriate Tasks

Battlefield Operating System	Sub-Class
INTELLIGIENCE	Manned Ground System
	Unmanned Ground System
	Manned Air System
	Unmanned Air System
MANEUVER	Direct Fire
	Infantry Fighting Vehicle/Armored Personnel Carrier
	Air Attack
FIRE SUPPORT	Indirect Fire
	Unmanned Ground System
AIR DEFENSE	
MOBILTY/COUNTERMOBILITY/ SURVIVABILITY	Manned Ground System
COMBAT SERVICE SUPPORT (CSS)	Fuel Truck
	Ammo Truck
	Air Utility
	Medical/Evacuation
	Personnel Carrier
COMMAND AND CONTROL (C2)	

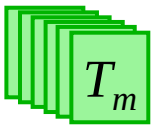
Chapter 1 ART 1.0: The Intelligence Battlefield Operating System
ART 1.3.3 CONDUCT TACTICAL RECONNAISSANCE
ART 1.3.3.1 CONDUCT A ZONE RECONNAISSANCE
ART 1.3.3.2 CONDUCT AN AREA RECONNAISSANCE
ART 1.3.3.3 CONDUCT A
ART 1.3.3.4 CONDUCT
ART 1.3.3.5 CONDUCT PATROL
ART 1.3.4 CONDUCT SURVEILLANCE

This is a new frontier for the V/L M&S community!

Requires (approval or) buy-in from the user community.

Data Development Process:

*Platform Tasks to Capability Matrix**



Current tasks determine which states are adequate.

	TASKS		Min Performing Task	MOBILITY (ART 2.2)					
				m0	m1	m2	m3	m4	m5
02:00-03:40, 03:51-04:17	ART 2.2	*LSI A1.2 Conduct Tactical Maneuver ART 2.2	126	m0	m1	m2	m3	m4	m5
			0.25			(m1 + m2)			
03:41-03:51, 04:20-10:00	ART 2.5	LSI A1.5.2 Occupy an Attack/Assault Position ART 2.5.2	350	m0	m1	m2	m3	m4	m5
			0.68						
03:41-03:51, 04:15-04:25	ART 3.3	*ART 3.3.1.1 Conduct Surface to Surface Attack	20						
			0.04						
03:47-03:52, 04:22-04:27, 04:38-04:43	ART 3.3	MTP 06-5-A008 Conduct Fire Missions	15						
			0.03						

Total minutes working tasks for NLOS-C in vignette = 511

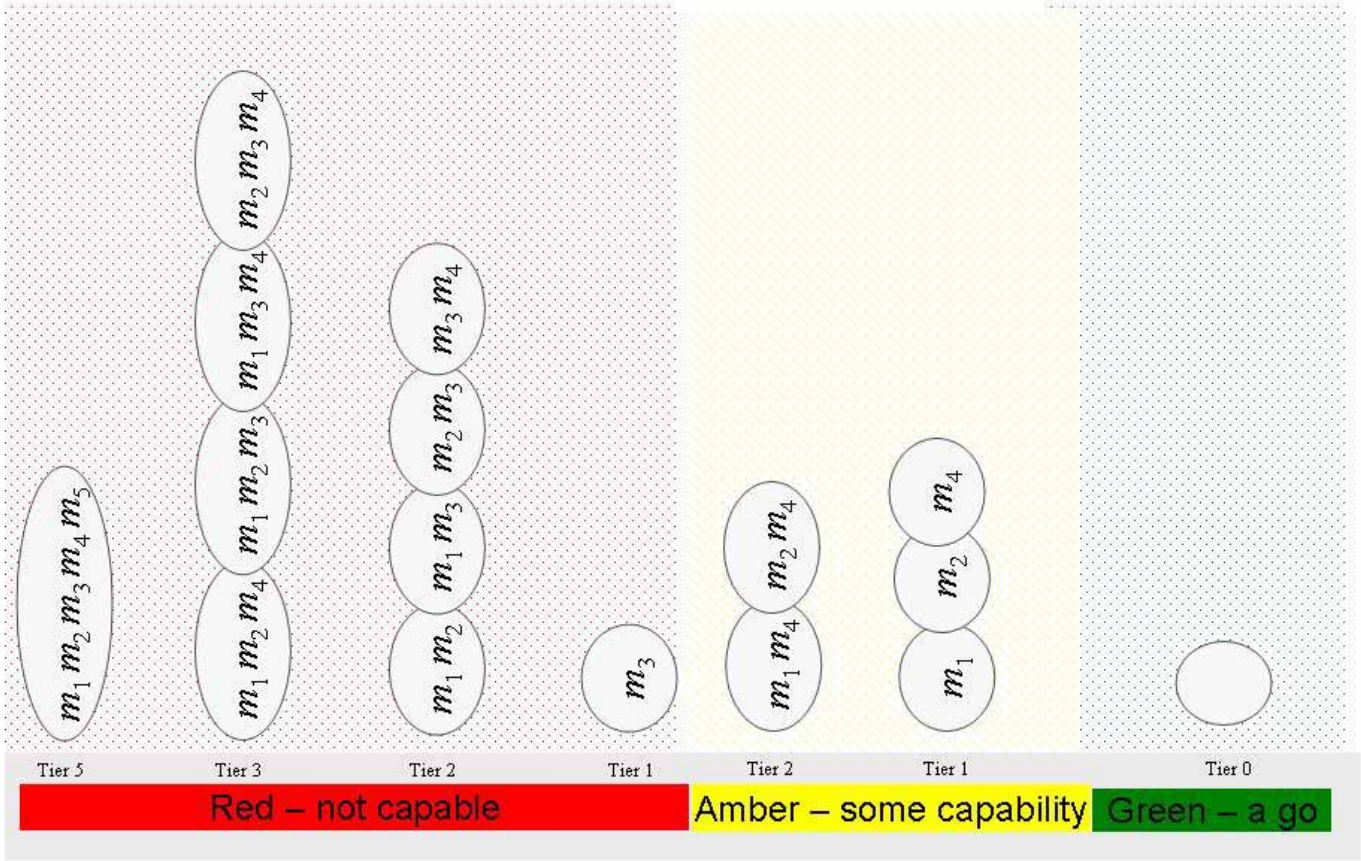
* MMF Demonstration

93% of the NLOS-C mission required some mobility.

Data Development Process:

Bin poset for Each Task

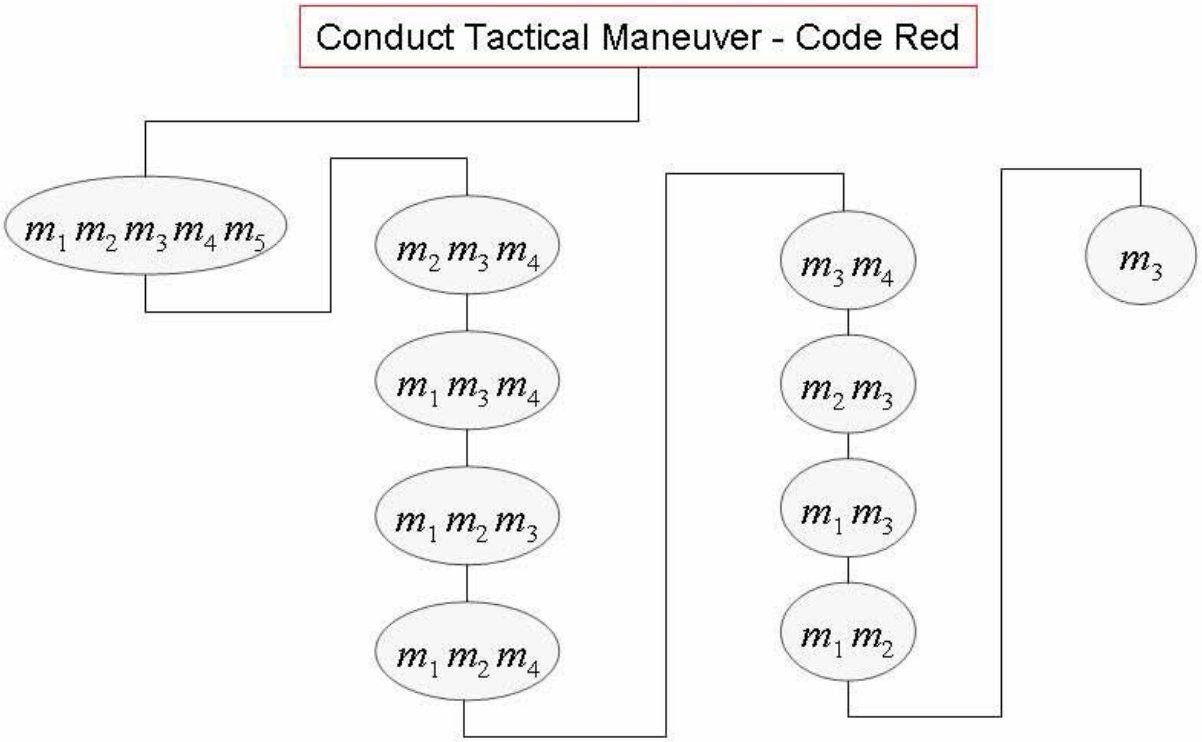
For task ART 2.2 LSI A1.2 Conduct Tactical Maneuver *.



* MMF Demonstration

Data Development Process:

Task-based Fault Tree Development



Data Development Process:
Calculate Probability of Degradation

TASK	Threat A		
	R	A	G
ART 2.2 Conduct Tactical Maneuver	.11	.15	.74
ART 2.5.2 Occupy Attack/Assault Position	.13	.14	.73
ART 3.3.1.1 Conduct Surface to Surface Attack	.21	.15	.64
MTP 06-5-A008 Conduct Fire Missions	.21	.15	.64
Mission Health Average	**.17**	**.15**	**.68**

Ballistic vulnerability as it relates to mission tasks.

Ballistic vulnerability as it relates to platform capability.

Capability	Threat A		
	R	A	G
Mobility	.20	.08	.72
Communications	.01	.04	.95
Crew	.00	.03	.97
Catastrophic	.04	N/A	N/A

Data Development Status

- Battlefield Operating Systems (BOS) have been mapped to platform subclasses, individual platforms in those classes, and associated tasks; database of this information is under development.
- ARL will be visiting Combined Arms Command (CAC) and the Futures Center to foster collaboration (BOS and AUTL/UJTL to platform assignment).
- There are plans to collaborate with TRADOC schools.
- ARL is developing MMF data for select Current Force systems.
- Several related M&S tools are under development to improve input development and results analysis.

The T&E community can leverage from these activities.

Implications

- **AUTL used for MMF can be used to support Operational Testing, i.e., what the system is supposed to do.**
- **Information from Developmental Testing can be incorporated into V/L modeling and validate Degraded Capability States.**
- **The same V/L modeling can be used to provide pre-shot predictions and support post-shot analysis during LFT&E.**
- **Low level tasks derived from an authoritative source such as the AUTL could be incorporated into Force-Level scenario development.**
- **The V/L data that supports the Force-level modeling could also be based on the same AUTL.**

System evaluation would have an auditable trail while reducing inconsistency and risk.